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MANNED UNDERWATER LABORATORY IN THE NORTH SEA
 INSTITUTE FOR AIR MEDICINE OF THE GERMAN
 RESEARCH INSTITUTION FOR AIR AND SPACE
 NAVIGATION AND BIOLOGICAL INSTITUTION
 HELGOLAND BUILD THE UWL "HELGOLAND"

Otto Kinne and Siegfried Ruff

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ABSTRACT: The design of the projected underwater laboratory (UWL) at Helgoland is briefly described. Provisions for the maintenance and medical surveillance of the laboratory personnel are indicated. The future research program, which consists of a medical, a psychological and a marine biology research program, is outlined.

The Biological Institution Helgoland (BAH) and the Institute for Air Medicine of the German Research Institution for Air and Space Navigation (DVL) intend to establish an underwater laboratory (UWL) in the North Sea. The total costs for construction, equipment and setting up of the UWL amount to DM 768.000. The further costs (personnel, servicing by supply ships, operation of the land station, etc.) will be defrayed by BAH and DVL. /1¹

The BAH is responsible for planning and carrying out the marine biological research projects, the employment of research ships and the assignment of work space to visiting researchers. The DVL is responsible for planning and carrying out the medical research projects as well as for the construction and preliminarily for the technical operation of the UWL.

Technical Description and Operation of the UWL

The laboratory is designed as a cylinder resistant to differential pressures of up to 10 atmospheres. This pressure corresponds to a water depth of 100 meters. Its useful volume amounts to 46 m³. It is divided for reasons of safety into 2 rooms, the so-called wet room and the working or sleeping room. In order to compensate for the tidal range of almost 3 m that is to be reckoned with in the vicinity of Helgoland, there is in the wet part a cylindrical entry and exit shaft that is about 3 meters long. This shaft can be closed water-tight if the tidal range, due to unfavorable weather, should exceed the normal value. Several observation windows in the wet part provide the opportunity to observe what goes on outside the laboratory. The four spraddled supporting legs are placed in longitudinally disposed ballast boxes. Air tanks that can be flooded and pumped out permit floating transportation of the laboratory and make a relatively easy change of position. All gas bottles needed for supply and containing compressed air, nitrogen, oxygen and helium are arranged in groups below the UWL. /2 /3

¹Numbers in the margin indicate pagination in the foreign text.

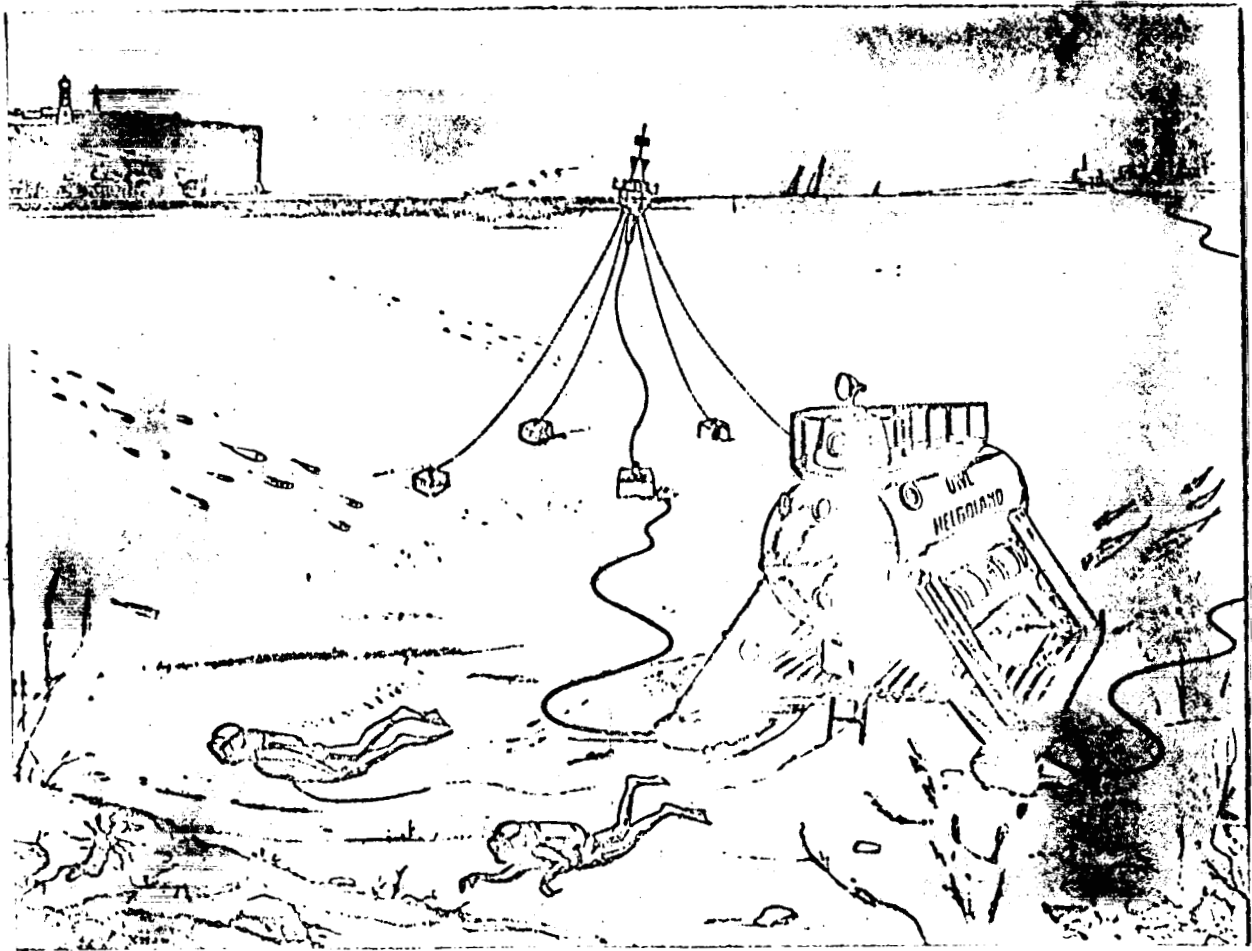


Fig. 1. Drawing of the Underwater Laboratory "Helgoland" at the Coast of the Island of Helgoland

The underwater laboratory is designed for the accommodation of 4 scientists. The duration of the stay is not subject to any limitations technically, since the atmosphere of the house is constantly being regenerated in a closed circuit, i.e. carbon dioxide and contaminants are absorbed or filtered out and used oxygen is replaced.

Speaking and television communication with the outside world as well as adequate supplies from the surface are prerequisites for frictionless operation. For the sake of safety, it is planned to carry telephone lines and power lines both to the shore and to a buoy floating above the UWL. In this buoy there is in addition to the television transmitter an automatically operating power generator unit. The buoy serves at the same time as antenna carrier for the television and radio communication and as position marker for the UWL.

If the power supply from these two sources should fail at the same time due to unforeseeable circumstances, a limited operation of the UWL can still be maintained for about 8 days from an emergency battery placed on the

framework of the laboratory. Supplies are placed in the laboratory for the same period, so that all connection with the surface of the water can be interrupted for this length of time without danger.

The surveillance of the laboratory takes place from a land station established in the vicinity of the "Dune-Oberfeuer" lighthouse. Here in addition to the electronic transmitting and receiving apparatus for radio and television, numerous measuring, control and recording devices will be installed for all technical operations in progress in the UWL.

Medical Prerequisites for the Operation of the UWL.

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A prerequisite for the tolerability of artificial gas mixtures is the maintenance of a definite carbon dioxide and oxygen concentration. While a carbon dioxide concentration of 0.005-0.01 atm must not be exceeded, the maximum permissible oxygen partial pressure depends on the duration of the stay. An oxygen partial pressure of 0.3-0.4 atm as is provided in the UWL can be tolerated for weeks without difficulty. For the first site at a depth of 15 m the use of compressed air would also be possible, but in that way the individual persons could only live in the UWL 6 days at a time.

While the choice of the gas mixture does not offer any particular problems, there are from a medical and psychological point of view other questions that must be considered. That concerns above all the living together in the most confined space in a closed atmosphere. It is known, and could also repeatedly be verified by our experiments, that as living together becomes so much more difficult, the more differentiated the individual personalities are. More experiences must be gathered in this area.

Medical Care and Check of the Persons Working in UWL.

The medical care and check of scientists and technicians working in the UWL is carried out with the following examination methods.

Electrocardiography.

Lung function tests (vital capacity, depth and rate of respiration), biochemical blood tests (determination of several enzymes and of the calcium and phosphorous level in the blood picture and urine check).

Psychological examinations (reaction time measurements, tapping and writing tests).

The care and checking program for the inhabitants of the underwater house is based on experiences of several years, gained through prolonged experiments under excess pressure. It has been found that this program was adequate in every case for judging the health situation.

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Medical Research Program

(1) Influence of effort on the function of heart and circulatory system inside and outside the UWL.

(2) Investigation of the influence of the water temperature on the core temperature of human beings.

(3) Investigation concerning the influence of nutrition on the efficiency and comfort of persons in the laboratory.

Psychological Research Program

The determination of the psychomotor efficiency has turned out in the experiments made so far to offer good opportunities for judging the condition of the test person. In the case of the inhabitants of the UWL it appears necessary in addition to investigate to what extent a man's perceptive faculty and ability to act are influenced or changed as compared with normal conditions. Especially such skills are to be investigated as those required for technical and mechanical work under water, and that both for rough and precision installation work. This psychomotor performance includes fine motor control, responsiveness, accuracy of movement and dexterity, also capability for spatial vision and judgment.

Research Projects in Marine Biology

The study of the ecological dynamics of marine life represents one of the most important research projects of our time. It is an urgent task of marine biological research to gain insight in the extremely complex structure of relationships between environment and organisms and thus to deepen our extremely incomplete knowledge of the anabolic, metabolic and catabolic processes.

The mastering of such extensive problems rises and falls with the development of suitable methods. The experiences of the last decades have shown that the methods of scientific skindiving and underwater television represent almost indispensable aids to the study of coastal waters. This living space for marine organisms, which is so exceedingly rich in forms and individuals could thereby for the first time be made accessible to direct observation. But by its nature the skindiving method is sharply limited by the limited stay for work under water.

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To attain the broad goal longrange experiments and correspondingly prolonged working periods under water are therefore indispensable to the marine biologist working in situ. Here the newest instrument of modern research, the underwater laboratory (UWL) offers its services.

The pioneer work performed by French and American scientists and engineers during recent years has brought to the attention of the world the fact that entirely new possibilities for both applied and basic research have been opened up by the employment of underwater laboratories, whose effect in depth and spinoff also into other scientific areas can hardly be overrated. While

the underwater stations hitherto constructed have been supported primarily by industrial and commercial interests, the first German UWL which is to be set up at Helgoland will primarily serve research in marine biology and medicine.

The American and French underwater laboratories have so far been established only in warm, clear and calm waters. With the Helgoland project important proof will now be produced that an UWL can also be successfully established in the waters of our country under relatively unfavorable environmental conditions (cold, moving water, partly with poor visibility).

Hitherto the marine biologist doing field work reported his findings almost exclusively on "fair weather days". But to understand the dynamics of life in the sea it is exactly the extreme situations (wind, water, current, turbidity, sediment transport) that are of decisive importance. The scientific ^{/7} diver team of the BAH has after 4 years of work in the North Sea acquired the necessary basic knowledge and important experience. Extensive research projects have already been carried out or initiated: the laying out of artificial underwater gardens, growth and assimilation measurements on brown algae, transplanting experiments on starfish, behavior studies on schools of fish, experimental ecological studies of the microfauna living in the sea sand. The group of problems in marine biology that can be encompassed by means of UWL may be outlined in a condensed summary as follows:

- 1) Expanding the range of our concept of the diversely structured life zones under water by direct observation.
- 2) Understanding the microclimatological data of stable and mobile seabottom in situ.
- 3) Qualitative and quantitative inventory of plant and animal organisms within circumscribed life zones.
- 4) Carrying out longrange experiments in situ.
- 5) Study and experimental verification of the behavior of marine organisms through direct observation.
- 6) Developing, elaborating and checking new collecting and catching methods in the light of experiences gained in the natural environment.

The Biological Institute Helgoland carries on basic research in the special fields of zoology, physiology, botany, microbiology, plancktonology, ichthyology, and radiation biology. It serves in addition as the only marine station of the mainland research institutions concerned. Accordingly the marine biology research projects that are to be carried out with the UWL are integrated with the research of the institute proper and in the studies of visiting researchers. The research programs under consideration are being worked out for a period of 2-3 years at a time. They are concentrated on relatively longrange experiments in situ and on the development of new working and research methods based on the UWL.

The establishment at some future time of UWL in other marine regions is contemplated.